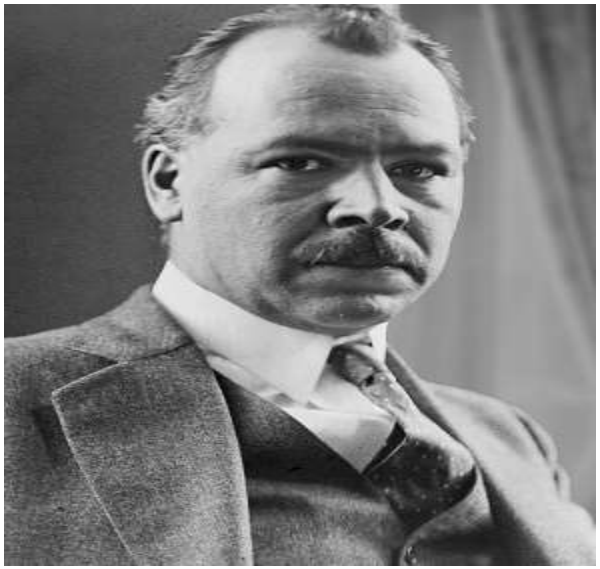
Plant breeding
Part 2

1. Centres of origin
2. Domestication
3. Introduction
4. Acclimatization
5. Selection
6. Hybridization

Centres of origin



- There is considerable evidence that the cultivated plants were not distributed uniformly throughout the world
- Even today certain areas show far greater diversity than others in the forms of certain cultivated crops and their wild relatives
- **N I Vavilov** proposed that,
- Crop plants evolved from wild species in the areas showing great diversity and termed them as primary centers of origin
- Later, crops moved to other areas primarily due to the activities of man
- These areas generally lack the richness in variation found in the primary centre of origin
- But in some areas, certain crop species show considerable diversity of forms although they did not originate there
- Such areas are known as Secondary centers of origin of these species

Concept of centre of origin was based on,

- Studies of vast collection of plants at the Institute of Plant Industry, Leningrad
- Vavilov was director of this institute from 1916-1936
- He also postulated the Law of Homologous Series in Variation
- This law states that, The characters found in one species also occur in other related species
- Thus Diploid (2x), Tetraploid (4x) and Hexaploid (6x) wheats show a series of identical contrasting characters
- Thus a character absent in a species, but found in a related species, is likely to be found in the collections of that species from the centre of its origin

8 Main centre of origin are recognized as proposed by Vavilov:

1. South America
2. Central America

2A. Chile Sub center

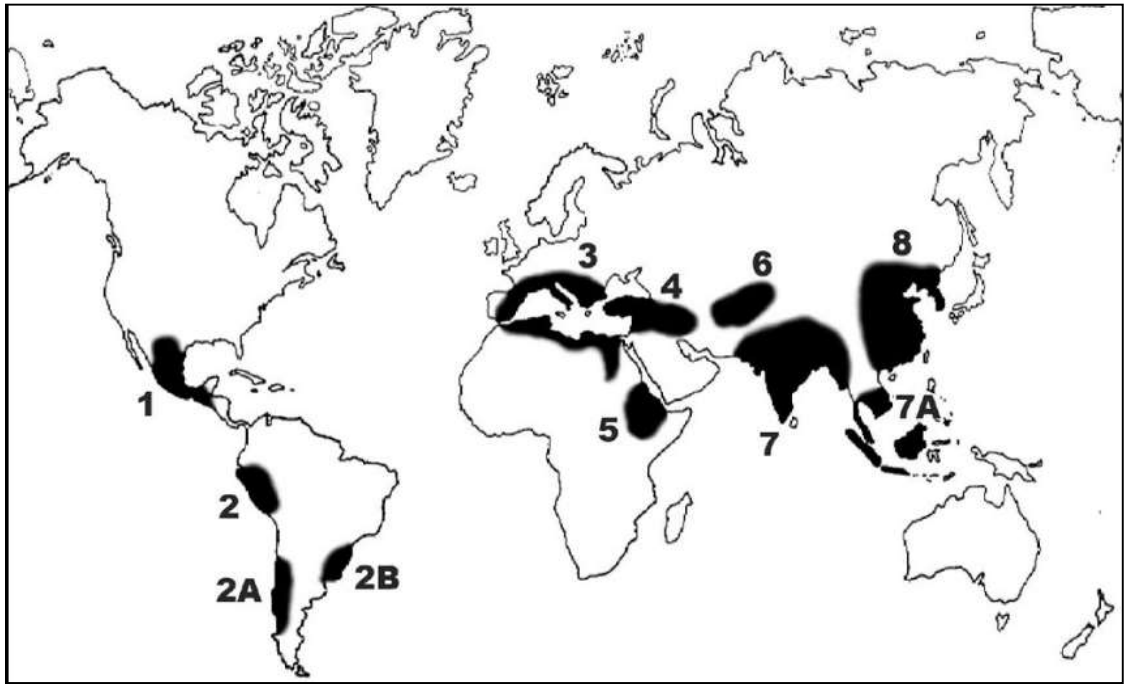
2B. Brazil-Paraguay sub center

3. Mediterranean
4. Asia Minor
5. Abyssinia
6. Central Asia
7. Hindustan

7A. Indo-Burma sub center

7B. Siam- Malaya- Java sub center

8. China



The China centre of origin

The Hindustan centre of origin

The Central Asia centre of origin

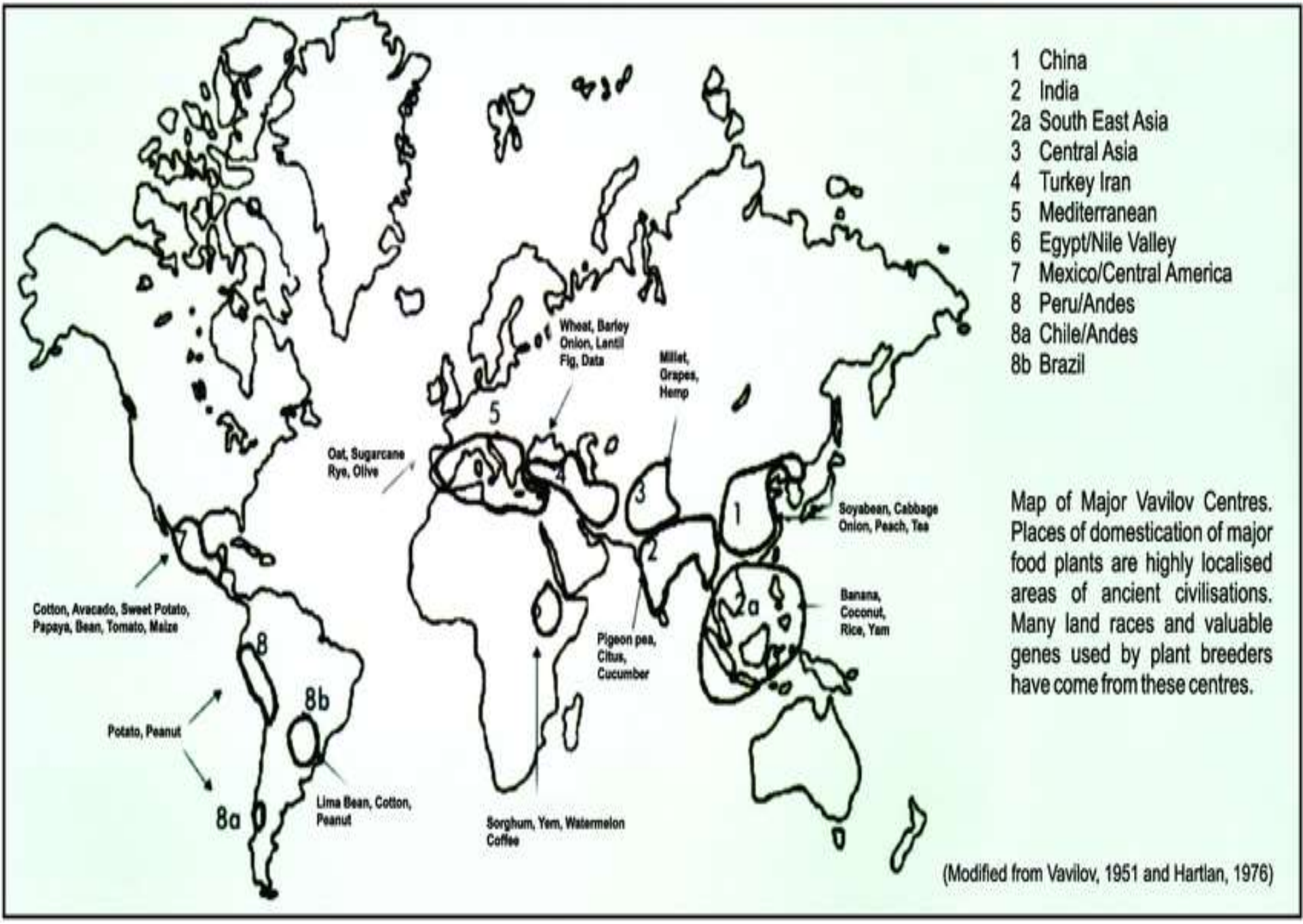
The Asia Minor centre of origin

The Mediterranean centre of origin

The Abyssinian centre of origin

The Central America centre of origin

The South America centre of origin


1 China
2 India
2a South East Asia
3 Central Asia
4 Turkey Iran
5 Mediterranean
6 Egypt/Nile Valley
7 Mexico/Central America
8 Peru/Andes
8a Chile/Andes
8b Brazil
Wheat, Barley
Onion, Lentil
Fig, Data
Millet,
Grapes,
Hemp
Oat, Sugarcane
Rye, Olive
Soyabean, Cabbage
Onion, Peach, Tea
Banana,
Coconut,
Rice, Yam
Pigeon pea,
Citus,
Cucumber
Cotton, Avacado, Sweet Potato,
Papaya, Bean, Tomato, Maize
Potato, Peanut
Lima Bean, Cotton,
Peanut
Sorghum, Yam, Watermelon
Coffee
Map of Major Vavilov Centres.
Places of domestication of major
food plants are highly localised
areas of ancient civilisations.
Many land races and valuable
genes used by plant breeders
have come from these centres.
(Modified from Vavilov, 1951 and Hartlan, 1976)

The China centre of Origin

Geography: Mountainous regions of central and western China and neighboring lower lands

Largest and oldest independent centre of origin

Crops originated in this area: **Primary centre of origin-**	**Secondary centre of origin-**
1. Soybean 2. Radish 3. Colocasia 4. Proso millet 5. Buck wheat 6. Opium poppy 7. Species of Brassica 8. Brinjal 9. Species of Cucumis and Cucurbita 10. Pears 11. Peaches 12. Apricots 13. Plums 14. Orange 15. Chinese tea 16. Naked oats	1. Maize 2. Rajma 3. Cowpea 4. Turnip 5. Sesame

The Hindustan Centre of Origin

Geography: Burma, Assam, Malaya Archipelago, Java, Borneo, Sumatra, Philippines but excludes North-West India, Punjab and North- western Frontier Provinces

Primary Centre of Origin-

1. Rice
2. Arhar
3. Gram/ chickpea
4. Cowpea
5. Mung
6. Brinjal
7. Cucumber
8. Indian lettuce
9. Yams
10. Indian radish
11. Noble canes
12. Cotton
13. Hemp
14. Black pepper
15. Indigo
16. Mango
17. Orange
18. Sour lime
19. Coconut
20. Banana
21. Turmeric

The Central Asia center of Origin

Geography: North-west India (Punjab, The North-west frontier Provinces and Kashmir), all of Afghanistan, The soviet Republics of Tajikistan and Uzbekistan and Tian-Shan
Also known as Afghanistan centre of origin

Primary centre of origin-	
1. Wheat	12. Muskmelon
2. Club wheat	13. Carrot
3. Pea	14. Onion
4. Broad bean	15. Garlic
5. Mung	16. Spinach
6. Linseed	17. Pistachio nut
7. Sesame	18. Apricot
8. Safflower	19. Pear
9. Hemp	20. Almond
10. Cotton	21. Grape
11. Radish	22. Apple
Secondary centre of origin-	
1. Rye	

The Asia Minor centre of origin

Geography: Interior of Asia Minor, the whole of Transcaucasia, Iran and Highlands of Turkmenistan
Also known as Near East or Persian Centre of origin

Primary centre of origin-	**Secondary centre of origin-**
1. 9 species of Triticum rye	1. Rape
2. Alfalfa	2. Black mustard
3. Persian clover	3. Leaf mustard
4. Carrot	4. Turnip
5. Cabbage	5. Apricot
6. Oat	
7. Lettuce	
8. Fig	
9. Pomegranate	
10. Apple	
11. Grapes	
12. Almonds	
13. Chestnut	
14. Pistachio nut	

The Mediterranean centre of origin

Geography: The entire Mediterranean region

Crops originates here: **Primary centre of origin**	
1. Durum wheats	11. Rape
2. Emmer wheats	12. Black mustard
3. Triticum species	13. Cabbage
4. Avena species	14. Turnip
5. Pea	15. Onion
6. Broad beans	16. Garlic
7. Lupins	17. Beets
8. Chickpea	18. Lettuce
9. Clovers	19. Artichoke
10. Vetch	20. Asparagus
	21. Lavender
	22. Peppermint
	23. Sage

The Abyssinian Centre of origin

Geography: Ethiopia, hill country of Eritrea

Primary centre of origin-	**Secondary centre of origin-**
1. Barley 2. Triticum durum 3. Triticum turgidum 4. Jowar 5. Bajra 6. Gram 7. Lentil 8. Sem 9. Pea 10. Khesari 11. Linseed 12. Safflower 13. Sesame 14. Castor 15. Coffee 16. Onion 17. Okra	1. Broad bean

The Central American Centre of origin

Geography: Region of South Mexico and central America
Also referred to as Mexican centre of origin

Crops originates in this regions:
Primary centre of origin:

1. Maize
2. Rajma
3. Lima bean
4. Melons
5. Pumpkins
6. Sweet potato
7. Arrowroot
8. Chilies
9. Cotton
10. Papaya
11. Guava
12. Avocado

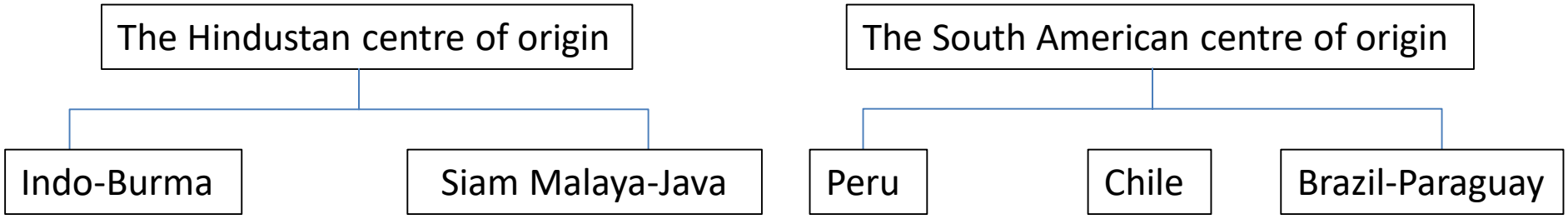
The South American Centre of origin

Geography: High mountainous regions of Peru, Bolivia, Ecuador, Colombia, parts of Chile and Brazil and whole Paraguay

Primary centre of origin-

1. Potatoes
2. Maize
3. Lima beans
4. Peanut
5. Pineapple
6. Pumpkin
7. Egyptian cotton
8. Tomatoes
9. Guava
10. Tobacco
11. Quinine tree
12. Cassava
13. Rubber

Later in 1935, Vavilov subdivided The Hindustan centre of origin and The South American Centre of origin



Importance of these centre of origin:

- Centre of diversity
- These centres may not be the centres of origin of species concerned, but they are the areas of the maximum diversity of these species
- This serves as an extremely useful guide to plant explorers as the where to search for variation in a given species
- Within large centres of diversity, small areas may exhibit much greater diversity than the centre as a whole. These areas are known as microcentres
- The crop evolution appears to proceed at a more rapid rate in these microcentres
- The microcentres are important for plant collection as well as for experimentally studying the evolution of plants

Domestication

Introduction

Acclimatization

Selection

Hybridization

Domestication

Definition:

Process of bringing wild species under human management

- 1st step in the development of cultivated plants was- domestication
- Most of crops were domesticated by the prehistoric man
- Under domestication, the crop species have changed considerably as compared to the wild species from which they originated
- The change is often so great that they are classified as distinct species
- The great differences between cultivated plants and their wild relatives was brought about by Selection by man or by nature

Natural and artificial selection under Domestication :

Selection: A phenomenon of some genotypes from a population leaving behind more progeny than others

- The genotypes more suited to a given environment leave behind more progeny than the less adapted ones- **Natural selection**
- It retains considerable variability in species
- The selection by man often permits only the selected plants to reproduce, the progeny from the remaining plants are discarded- **Artificial selection**
- It progressively recues the variability

Changes in plant species under domestication :

1. Elimination of or reduction in shattering of pods, spikes.
2. Elimination of dormancy in several crop species
3. Decrease in toxins or other undesirable substances
4. Plant type has been extensively modified
5. The cultivated plants show altered tillering, branching, leaf characters
6. Decrease in plant height in some cereals and millets
7. Increase in plant height in jute, sugarcane
8. Lifecycle has become shorter in cotton, arhar
9. Increase in size of grains or fruits
10. Increase in economic yields
11. Asexual reproduction is promoted
12. Reference of polyploidy increased
13. Shift in sex form of the species
14. Self incompatibility has been eliminated
15. Decrease in variability within variety

Introduction

Definition:

A process of talking a genotype or a group of genotypes of plants into new environments where they were not being grown before

- Often the materials are introduced from other countries or continents
- Movement of crop varieties from one environment to another within a country is also a plant introduction

Two Categories:

Primary Introduction

Secondary Introduction

Primary introduction:

- When the introduced variety is well suited o the new environment, it is released for commercial cultivation without any alteration in the original genotype
- It is less common, particularly in countries having well organized crop improvement programmes
- Ex. Introduction of semi dwarf wheat varieties Sonora 64 and Lerma Rojo

Secondary introduction:

- The introduced variety may be subjected to selection to isolate a superior variety.
- It may be hybridized with local varieties to transfer one or few characters from this variety to the local varieties
- Much more common than primary introduction
- Ex. Kalyan sona and Sonalika wheat variety selected from materials introduced from CIMMYT

Purpose of plant introduction:

- To obtain an entirely new crop plant
- To serve as new varieties
- To be used in crop improvement
- To save the crop from diseases and pests
- For scientific studies
- Aesthetic value

Plant introduction agencies in India :

1. National bureau of Pant genetic resource (NBPGR)
2. Indian Agricultural Research Institute (IARI)

Procedure of plant introduction:

1. Procurement of germplasm
2. Quarantine
3. Cataloguing
4. Evaluation

Merits of plant introduction:

- It provides entirely new crop plants
- May provide superior varieties directly, after selection or hybridization
- Introduction and exploration are the only feasible means of collecting germplasm and to protect variability from genetic erosion
- Very quick and economical method of crop improvement
- Plants may be introduced in new disease free areas to protect them from damage

Demerits of plant introduction:

- Introduction of weeds diseases and pests to new environment
- **Weeds-** Argemone mexicana, Eicchornia crassipes, Phylaria minor
- **Diseases-** Late blight of potato, Bunchy top of banana
- **Insect pests-** Potato tuber moth, woolly aphis

Acclimatization

Definition:

Process that leads to the adaptation of a variety to a new environment

- It is brought about by a faster multiplication of those genotypes (present in the original population) that are better adapted to the new environment
- Thus it is essentially natural selection
- Variability must be present in the original population for acclimatization to occur
- Land varieties are likely to get acclimatized ,while a pureline is not likely to do so

Extent of acclimatization is determined by,

- The mode of pollination
- The range of genetic variability in the original population
- The duration of life cycle of the crop
- Cross pollination leads to far more gene recombination's than self pollination and is much more helpful in acclimatization than self pollination
- Greater the variability, the more extent of acclimatization

Selection

1. In self pollinated crops

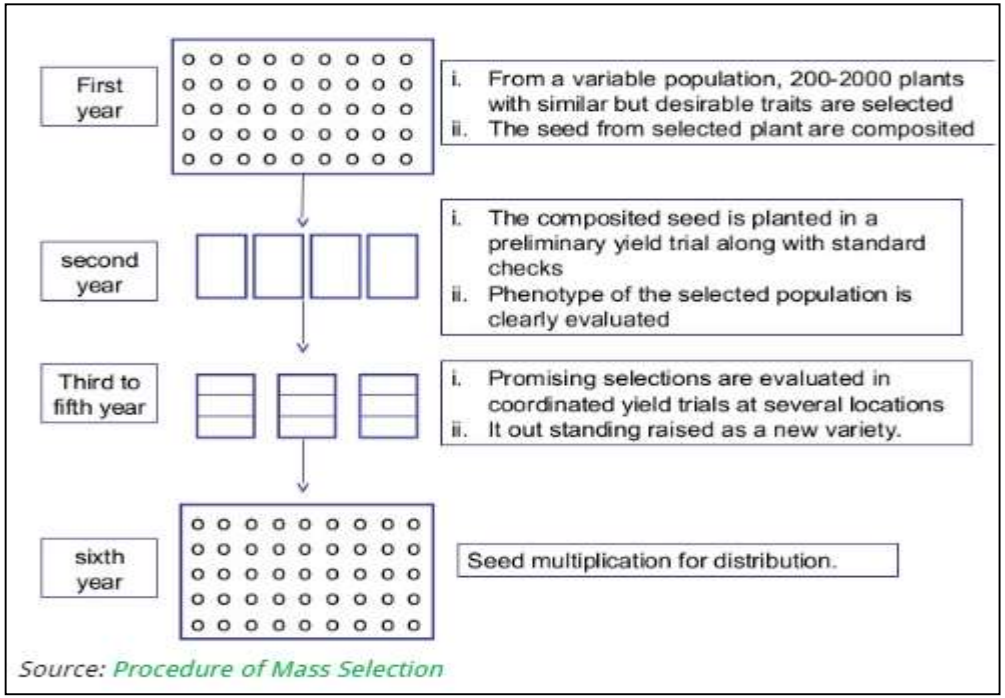
- Selection permits reproduction only in those plants that have desirable characteristics
- Achieved by raising the next generation from seeds produced by the selected plants only
- Selection s based on phenotype of plants

Two requirements for selection:

1. Variation must be present in the population
2. Variation must be heritable

Purpose of selection:

- To isolate desirable plant types from the population
- The basis of crop improvement


First year
i. From a variable population, 200-2000 plants with similar but desirable traits are selected
ii. The seed from selected plant are composited
second year
i. The composited seed is planted in a preliminary yield trial along with standard checks
ii. Phenotype of the selected population is clearly evaluated
Third to fifth year
i. Promising selections are evaluated in coordinated yield trials at several locations
ii. It out standing raised as a new variety.
sixth year
Seed multiplication for distribution.

Source: *Procedure of Mass Selection*

2**. In cross pollinated crops**

Selection is done to,

- Change the mean in the direction of selection
- Increases the frequency of desirable alleles and genotypes
- Leads to the production of new genotypes
- May or may not reduce genetic variance

Five different types of responses to selection:

1. Rapid gain followed by a period of slow gain is seen in characters governed by few major genes and several minor genes
2. Slow gain for a long time is characteristic of traits governed by polygenes; contribution of each gene is small but the heritability is high
3. Slow gain ending in a plateau (found in case of those quantitative characters where change due to selection beyond a limit is prevented by physiological limitations)
4. Little or no gain produced Characteristics of those quantitative characters that have low heritability eg. Yield,
5. Rapid gain- plateau- rapid gain result from the release of potential variability
   Initial response to selection, is due to free variability present in the form of blocks of linked genes

The progeny test:

Evaluation of the worth of plants on the basis of performance of their progenies

The real value of a plant can be known only by studying the progeny produced by it

Functions:

To determine the breeding behaviors (whether it is homo or heterozygous)

To find out whether the characters for which the plant was selected is heritable (i.e. due to genotype)

The pureline theory:

A pureline is progeny of a single homozygous plant of a self pollinated species

All plants in a pureline have the same genotype

The phenotypic differences within a pureline are due to the environment(natural hybridization, mechanical mixture, mutation, chromosomal aberrations, etc

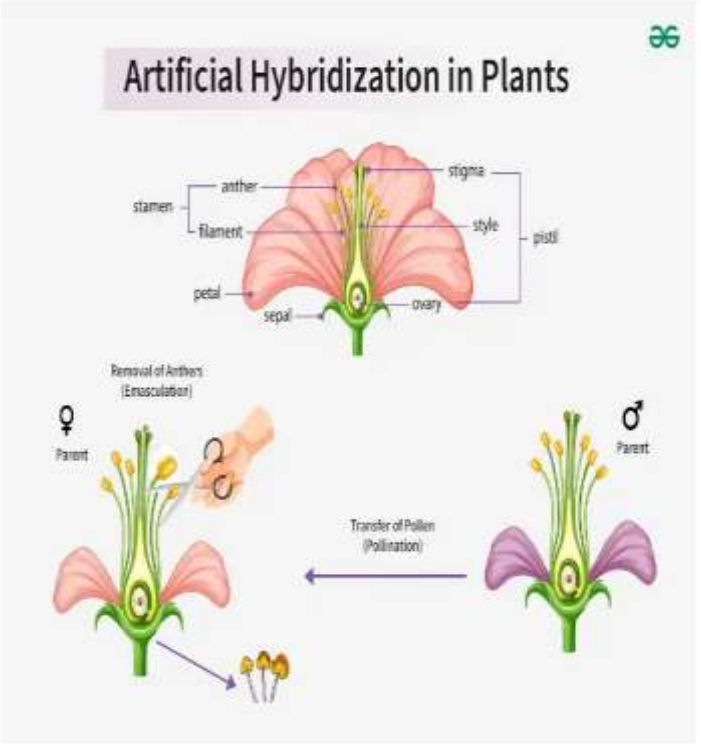
Therefore variation within a pureline is not heritable

Hybridization

Definition:

The mating or crossing of two plants or lines of dissimilar genotype

- In plants, crossing is done by placing pollen grains from one genotype, the male parent, on to the stigma of flowers of the other genotype, the female parent
- The seeds as well as the progeny resulting from the hybridization are known as Hybrid/ F1
- The progeny of F1, obtained by selfing or intermating of F1 plants and the subsequent generations are termed as segregating generations



Artificial Hybridisation in Plants

Objectives of hybridization:

- To create genetic variation
- Transfer of one or few qualitative characters
- Improvement of one or more quantitative characters
- Use of F1 hybrid as hybrid variety
- **Combination breeding-** transfer of one or more characters into a single variety from other varieties
- **Transgressive breeding-** improving yield or its contributing characters through transgressive segregation (Production of plants in an F2 generation that are superior to both the parents for one or more characters)

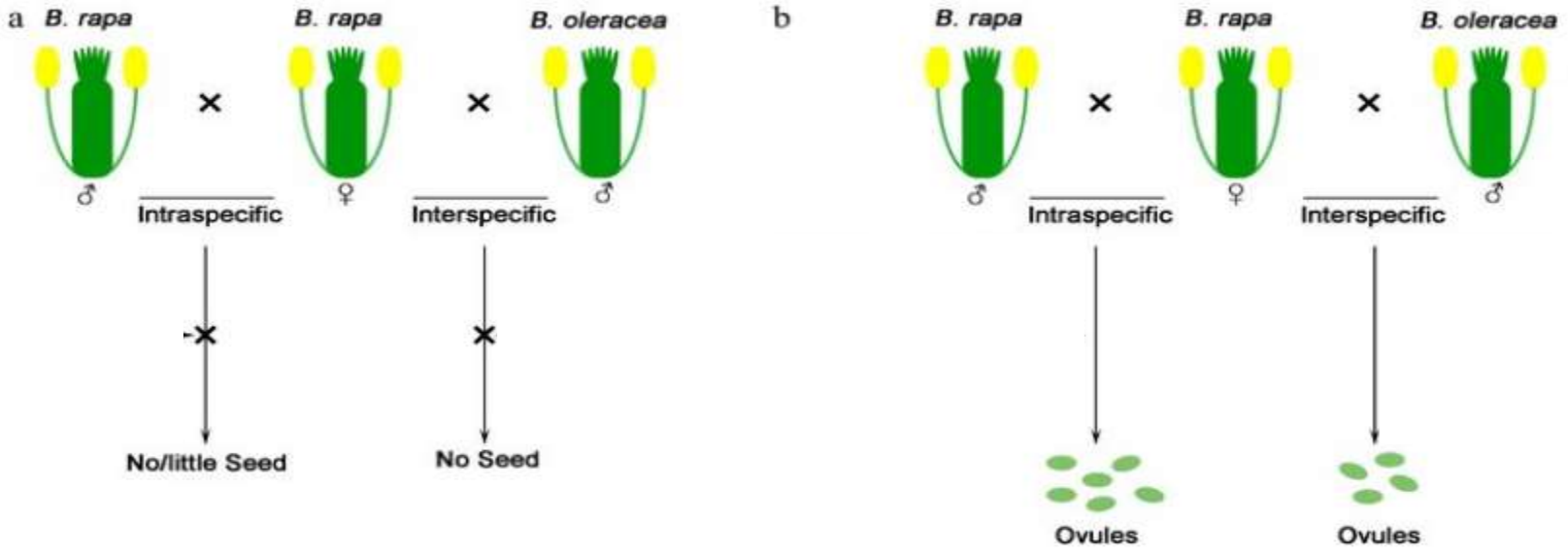
Types of hybridization:

2 Groups:

1. Intervarietal hybridization
2. Distant hybridization

Intervarietal hybridization:

- Parents involved in hybridization belong to the same species; they may be two strains, varieties or races of the same species
- Also called as intraspecific hybridization
- Most commonly used method in crop improvement programmes
- Ex. Crossing of varieties of wheat, rice or some other crop
- Based on number of parents involved crosses may be, simple crossing (2 parents) and complex cross (more than 2 parents)



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Distant hybridization:

- Crosses between different species of the same genus or of different genera
- When 2 species of the same genus are crossed- interspecific hybridization
- When they belong to two different genera are crossed- intergeneric hybridization
- Ex. Crossing of Clinton oat with Avena species

Procedure of hybridization:

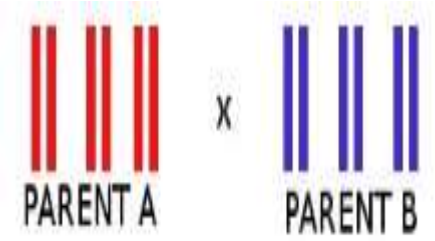
1. Choice of parents
2. Evaluation of parents
3. Emasculation
4. Bagging
5. Tagging
6. Pollination
7. Harvesting and storage of F1 seed

Merits of hybridization:

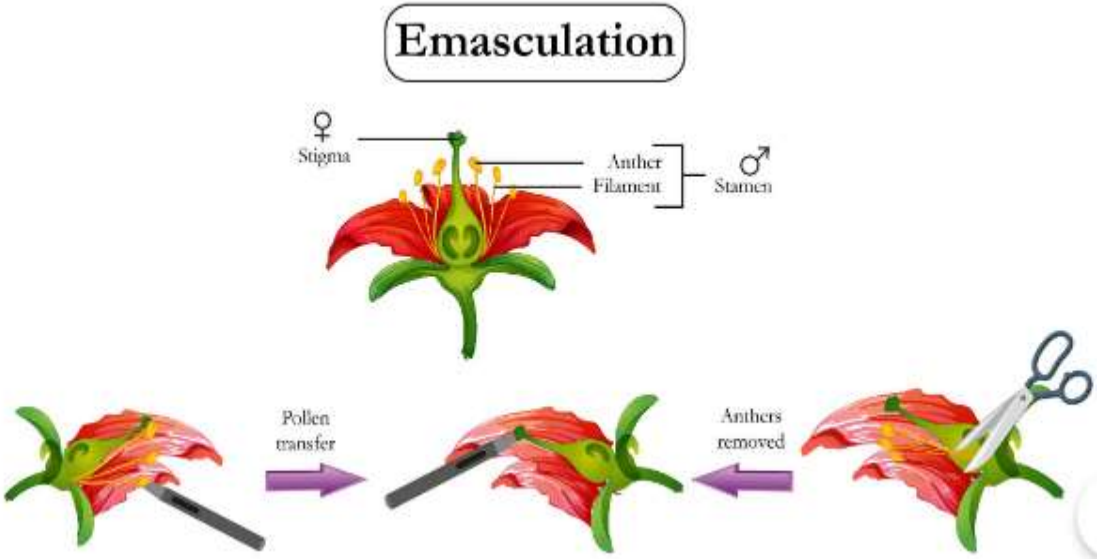
1. Increased yield
2. Improved disease resistance
3. Production of new trait combination
4. Adaptability to different environments
5. Improved quality characteristics
6. Combining resistance genes
7. Improved growth

1. **Choice of parents**: At least one parent involved in cross should be a well adapted and proven variety in the area
   - Other parent should have characters that are absent in this variety
   - Parents should have combining ability

2. **Evaluation of parents**: If performance of parents are not known, it should be determined, particularly for the characters they are expected to contribute and for disease resistance
   - New strains should also be checked for mechanical mixture and for heterozygosity



3. **Emasculation**: *Removal of stamens or anthers or the killing of pollen grains of a flower without affecting in any way the female reproductive organs*

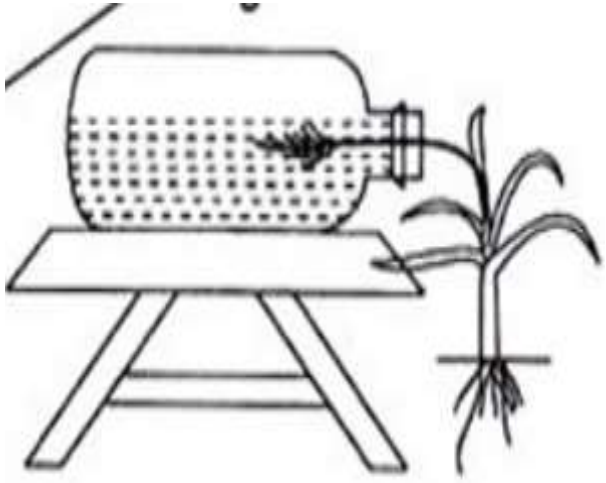


https://www.vedantu.com/question-answer/meant-by-emasculation-how-is-it-useful-in-a-class-12-biology-cbse-5f9713eff231cf558a30fee0

To prevent self- fertilization in the flowers of female parent

- In Dioecious plants, male plants are removed
- In Monoecious species, male flowers(eg. In castor) or the male inflorescence (maize) are removed
- In bisexual flowers, emasculation is must.
  - **Hand emasculation** (for species of large flowers)
  - **Suction method** (for species of small flowers)
  - **Hot water treatment** (in jowar)
  - **Alcohol treatment** (in sweet clover),
  - **Cold treatment** (in rice),
- **Genetic emasculation** (genetic or cytoplasmic male sterility may be used to eliminate the necessity of emasculation)
- In Species of self incompatibility, (emasculation not necessary)

Hand emasculation



Suction method

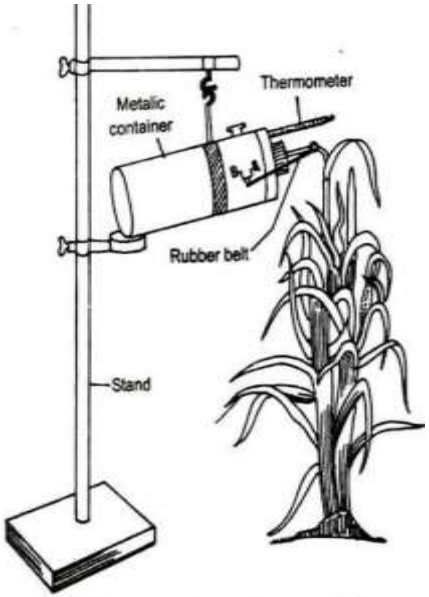


Fig. 7. Hot water equipment for emasculation.

Hot water treatment

4. **Bagging**: Immediately after emasculation, the flowers or the inflorescence are enclosed in suitable bags of appropriate sixe to prevent random cross pollination
   - In cross pollination crops, (Maize) male flowers are also bagged to maintain the purity of pollen used for pollination
   - Bags used: paper bags, butter paper bags, glassine bags, fine cloth bags, vegetable parchment bags

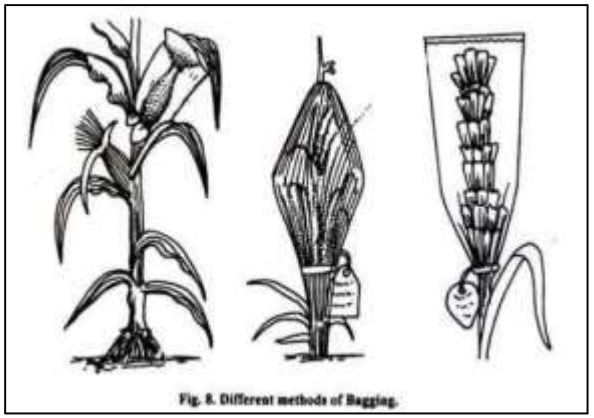
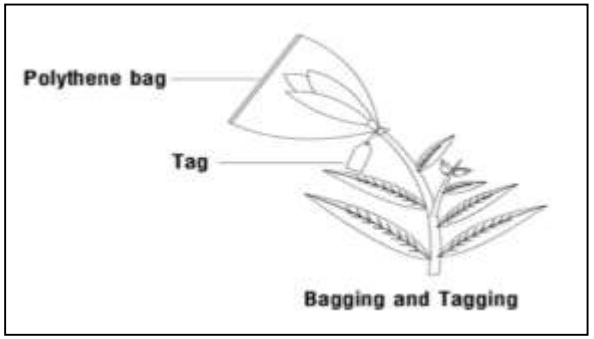


Fig. 8. Different methods of Bagging.

5. **Tagging**: emasculated flowers are tagged just after bagging. Attached to the flower or the inflorescence with the help of thread details should be mentioned(date of emasculation, date of pollination, names of female and male parents etc.)



Bagging and Tagging

6. **Pollination**: process of collecting pollen from freshly dehisced anthers of the male parent and dusting this pollen on the stigma of emasculated flowers
   - Harvesting and storing F1 seeds: the crossed heads or pods should be harvested and threshed
   - Seeds should be dried and properly stored to protect them from storage pests
   - Raising the F1 generation: Selfing to avoid cross pollination and to ensure self pollination